**Robert L. Ehrlich, Jr.**
*Governor*
**Michael S. Steele**
*Lt. Governor*

**C. Ronald Franks**
*Secretary*

**Chapter 2 – Tree Biology and Physiology**

Maryland DNR Forest Service – Urban & Community Forestry
Internet: www.dnr.maryland.gov Phone: 410-836-4568

## Tree Biology & Physiology

**Objective**

To learn how a tree grows and functions in order to care for it and manage it in a way that supports its growth & development.

## Tree Biology & Physiology

**Tree Biology**: The study of structure and function and the relationship between them.

- **Anatomy** = the study of the component parts of a tree.
- **Physiology** = the study of the biological and chemical processes within the tree.

## Tree Biology & Physiology

**Tree Anatomy**

Cells are the basic building blocks.

In plants, new cells come from the division of existing cells.

## Tree Biology & Physiology

**Tree Anatomy**

Tree cell division occurs in structures called **meristems**.

Following division, cells undergo **differentiation**, which changes structure and allows cells to assume specific functions.

## Tree Biology & Physiology

**Tree Anatomy**

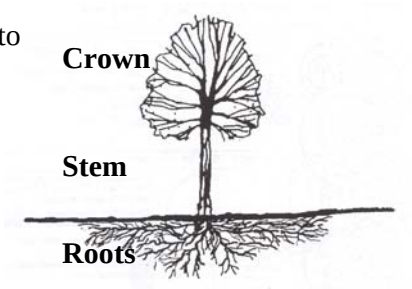
Primary meristems are located at the ends of shoots and roots and are called **apical meristems**.

Lateral buds may be inhibited by the active growth of terminal buds. This is called **apical dominance**.

## Tree Biology & Physiology

**Trees**

Trees are divided into three majors parts:




## Tree Biology & Physiology

**Trees**

In a forest community, trees occupy different positions in the canopy and understory called **crown classes**.

Crown Classes (D) Dominant, (CD) Co-Dominant, (I) Intermediate, And (S) Suppressed

## Tree Biology & Physiology

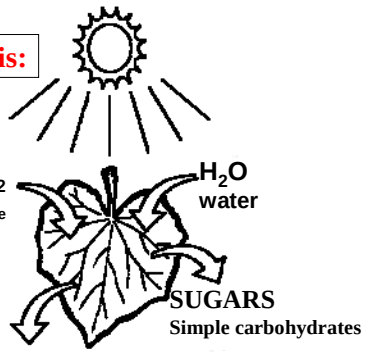
**Leaves**

**Leaves** are the food producers of the tree.

Leaf functions:

1. Photosynthesis
2. Transpiration
3. Respiration

**Photosynthesis is:**




Process of turning carbon dioxide and water into simple carbohydrates and oxygen using the energy of the sun.



## Tree Biology & Physiology

**Leaves**

Trees that lose their leaves every year are called **deciduous**.

Trees that hold their leaves for more than one year are called **evergreen**.

## Tree Biology & Physiology

**Leaves**

Needles and scales of conifers perform the same function as leaves of broadleaf trees.

## Tree Biology & Physiology

**Leaves**

Too little or too much soil moisture can result in leaf-water deficits.

Water deficits can cause:

- Slowed photosynthesis;
- Stomatal closure;
- Wilting leaves.

## Tree Biology & Physiology

**Leaves**

Fall color results from the breakdown of green chlorophyll & the expression of other pigments which are always present.

Kenneth M. Gale, , www.forestryimages.org

Anthocyanins = reds and purples

Carotenoids = yellows, oranges and reds

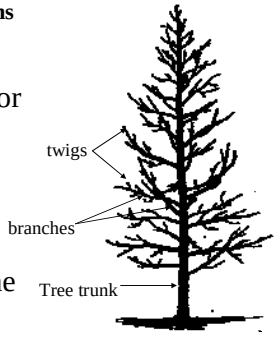
## TREE BIOLOGY

**Stems**

**Twigs** are small stems that provide support structure for leaves, flowers and fruit.

**Branches** support twigs.

The **tree trunk** supports the entire **crown**.



## Tree Biology & Physiology

**Stems**

The **stem** of the tree functions in:

1. Conduction of water & minerals;
2. Support of the tree;
3. Storage of reserves;

## Tree Biology & Physiology

**Stems**

The **cambium** is a thin, continuous sheath of radially dividing cells that produces:

xylem (to the inside) and,

phloem (to the outside).

## Tree Biology & Physiology

**Stems**

**Growth rings** are the annual production of xylem by the cambium.

They are visible because of the contrast between earlywood growth (light color) and latewood growth (dark color).

## Tree Biology & Physiology

**Stems**

**Xylem**, (the area of active, living wood) functions to:

- Transport water & nutrients;
- Store food and water; and
- Provide support.

## Tree Biology & Physiology

**Stems**

**Xylem**, which functions to transport water and nutrients, is called **sapwood**.

Farther inside the tree is the **heartwood**. It is composed of dead cells and provides support for the tree.

## Tree Biology & Physiology

**Stems**

**Phloem** carries sugars and food down from the leaves to the rest of the tree.

**Xylem** carries water and nutrients up from the roots to the rest of the tree.

## Tree Biology & Physiology

**Stems**

The outer covering of a tree branches & stems is the **bark**.

Functions:

•Moderate temperature

•Defense against insects & injury

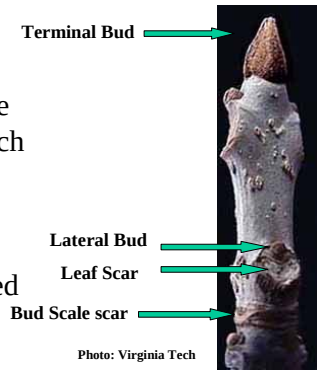
•Reduces water loss.

Small openings in the bark, **lenticels**, allow for gas exchange.

## Tree Biology & Physiology

**Buds** can occur along the twig, at the base of each leaf, just under the bark, or at the tip of each twig.

A **bud** is an unexpanded shoot or flower.




## Tree Biology & Physiology


**Buds** can occur along the twig, at the base of each leaf, just under the bark, or at the tip of each twig.

Terminal bud scale scars are useful in measuring **annual** twig elongation.

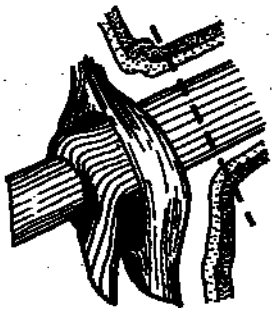

You can measure a tree annual growth by measuring the distance between terminal bud scale scars

Photo: Virginia Tech

## Tree Biology & Physiology

**Stems**

The annual production of layers of tissue at the junction of the branch to the stem forms a shoulder or bulge called the **branch collar**.





## Tree Biology & Physiology

**Stems**

**REACTION WOOD** is wood altered to counteract a lean in a tree.

Conifers form compression wood as a type of reaction wood.

In hardwoods, cell walls thicken on the upside of the lean; hardwoods have tension wood as a type of reaction wood.

## Tree Biology & Physiology

**Roots**

The roots serve four primary functions:

1. Anchorage
2. Storage
3. Absorption
4. Conduction

## Tree Biology & Physiology

**Roots**

The root system of tree may comprise 1/3 to 1/2 the entire volume of a tree.

## Tree Biology & Physiology

**Roots**

Many roots live in a symbiotic relationship with certain fungi. The result is termed **mycorrhizae (fungus roots)**.

**Symbiosis -** The fungi derive nourishment from the roots.

The fungi aid the roots in absorption of water and essential mineral elements.

## Tree Biology & Physiology

**Flowers**

The flower is the reproductive unit of some trees.

Parts of the flower include petals, sepals, one or more carpels (the female reproductive organs), and stamens (the male reproductive organs).

## Tree Biology & Physiology

**Flowers**

A complete flower is one that contains all four floral organs:

→ Petal;

→ Sepal;

→ Stamen;

→ Carpels.

## Tree Biology & Physiology

**Fruit**

**Tree fruit takes many shapes and forms.**

**Angiosperms** = flowering plants whose seed is enclosed in an ovary.

**Gymnosperms** = "naked seeds"
plants whose seeds are borne with no outer covering.

## Tree Biology & Physiology

**Physiology**

Physiology is the study of the biological and chemical processes within a living structure.

## Tree Biology & Physiology

**Photosynthesis**

Photosynthesis is the process by which green plants use light to build sugar molecules.

Literally = “putting together with light”

## Tree Biology & Physiology

**Photosynthesis**

$$6H_2O + 6CO_2 \text{ ----------> } C_6H_{12}O_6 + 6O_2$$

Six molecules of water plus six molecules of carbon dioxide produce one molecule of sugar plus six molecules of oxygen.

## Tree Biology & Physiology

**Photosynthesis**

Much of the photosynthate is stored in the form of sugar or starch in the twigs, trunk and roots for later energy requirements.

## Tree Biology & Physiology

**Respiration**

**Respiration** is the process by which chemical energy is used by the tree for all of its biological functions.

In the process, the bonds of sugars and starches are broken, yielding energy, carbon dioxide and water.

Respiration occurs at all times.

Oxygen is required for normal respiration to occur.

## Tree Biology & Physiology

**Respiration**

The energy created and stored by photosynthesis must be greater than the energy used in respiration.

Otherwise…

The tree must use its energy reserves. If this occurs over time, the tree may run out of energy reserves and die.

## Tree Biology & Physiology

**Transpiration**

**Transpiration** is the loss of water in the form of water vapor from leaf surfaces.

The evaporation of water cools the the leaves & creates a “transpirational pull” that moves water up through the xylem.

## Tree Biology & Physiology

**Transpiration**

The rate of transpiration is affected by temperature, humidity and available water.

Transpiration is also affected by cuticle thickness, presence of hairs on the leaf surface, and number and location of stomata.

i.e. Plants with thick cuticle, small leaves, sunken stomata are adapted to hot & dry conditions.

## Tree Biology & Physiology

**Absorption, Transpiration and Vascular System**

Water and essential elements are absorbed from the soil by the roots.

Some water is used for growth & metabolism, but most lost through evaporation.

This water loss creates “transpirational pull” that moves water through the xylem.

## Tree Biology & Physiology

**Absorption, Transpiration and Vascular System**

The **xylem** can be thought of as a continuous column of water, where the evaporation of molecules from the leaves pulls the water up through the tree.

## Tree Biology & Physiology

**Absorption, Transpiration and Vascular System**

If the water potential is lower in the soil, water will actually move out of the roots into the soil.

Ex: When salt concentrations are high in the soil from deicing or excessive fertilization application.

## Tree Biology & Physiology

**Absorption, Transpiration and Vascular System**

**Radial transport** is the horizontal movement or water or nutrients between cells through ray cells.

## Tree Biology & Physiology

**Absorption, Transpiration and Vascular System**

**Rays** are channels of cells where water, nutrients & carbohydrates move laterally.

## Tree Biology & Physiology

**Control of Growth and Development**

| | |
|---|---|
| **Excurrent** trees have: | **Decurrent** trees have: |
| Strong apical control; | Weak apical control; |
| Strong central leader; | No strong central leader; |
| Cone-shaped crown. | Diffuse crown. |

## Tree Biology & Physiology

**CODIT**

A developmental process unique to trees is the ability to departmentalize decay.

**Compartmentalization** is the process by which trees react to injury by forming physical and chemical barriers to contain the injury and its effects.

## Tree Biology & Physiology

**CODIT**

After a tree is wounded, reactions are triggered to form boundaries around the wounded area.

A model of this process is called **CODIT** =

**C**ompartmentalization **O**f **D**ecay **I**n **T**rees

## Tree Biology & Physiology

**CODIT**

Trees form 4 walls around a decayed area.

Wall 1 – stops decay spreading vertically;

Wall 2 – limits decay spread inward;

Wall 3 – Limits lateral spread of decay;

Wall 4 – stops decay spread to new wood growth

## Tree Biology & Physiology

**CODIT**

It is fairly common for wall 1,2 and 3 to fail.

Wall 4 rarely fails, except where canker-causing fungi restrict its development or kill the cambium.

Wall 4 is considered to be the strongest wall.

## Tree Biology & Physiology

**CODIT**

Wall 4 forms to stop the spread of decay to the new wood growth as the tree grwos radially.

Tod Ericson, MD DNR Forest Service

## Tree Biology & Physiology

**CODIT**

Wall 4 is almost closed.


Tod Ericson, MD DNR Forest Service

## Tree Biology & Physiology

**CODIT**

Wall 4 has completely closed to prevent decay from spreading to new wood as the tree grows out around it.


Tod Ericson, MD DNR Forest Service

Maryland Department of Natural Resources-Forest Service

Urban & Community Forestry Program

Visit us on our website at www.dnr.maryland.gov

**Robert L. Ehrlich, Jr.**
***Governor***
**Michael S. Steele**
*Lt. Governor*
**C. Ronald Franks**
*Secretary*